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COAL STRENGTH PARAMETERS DERIVED FOR THE NO. 1 (SCOTT PIT) SEAM, DRUMMOND MINE, WESTVILLE, N.S.

T.R.C. Aston, L.S. O'Leary and D.J. O'Brien
Cape Breton Coal Research Laboratory

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by

T.R.C. Aston*, L.S. O'Leary** and D.J. O'Brien**

SUMMARY

As part of ongoing geotechnical research activities at the Cape Breton Coal Research Laboratory, samples were collected from the No. 1 (Scott Pit) seam at the Drummond Mine, Westville, N.S. A programme of irregular lump point load testing was undertaken and uniaxial and tensile strength parameters derived. Strength values are given both parallel and perpendicular to the bedding plane and an anisotropy index calculated. A preliminary comparison between the Pictou and Sydney Coalfield data reveals that the Drummond coal properties closely resemble those obtained from Prince Mine.

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DÉTERMINATION DES PARAMÈTRES DE RÉSISTANCE DU CHARBON DU GISEMENT N° 1 (SCOTT PIT) DE LA MINE DRUMMOND, WESTVILLE (N.-É).

par

T.R.C. Aston*, L.S. O'Leary** et D.J. O'Brien**

RÉSUMÉ

Dans le cadre des activités de recherches géotechniques effectuées au Laboratoire de recherche sur le charbon du Cap-Breton, on a prélevé des échantillons du gisement n° 1 (Scott Pit) de la mine Drummond de Westville (N.-É). On a entrepris un programme d'essais discontinus de charge concentrée et on a déterminé les paramètres de résistance à la compression uniaxiale et à la rupture. On a fait l'appréciation de la résistance parallèle et perpendiculaire au plan de stratification ainsi que le calcul de l'index d'anisotropie. Une comparaison préliminaire les données des houillères de Pictou et de Sydney démontre que les propriétés du charbon de Drummond sont très semblables à celles du charbon provenant de la mine Prince.

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INTRODUCTION

The Cape Breton Coal Research Laboratory (CBCRL) as part of its on-going coal mining related research activities is currently establishing a geotechnical data base of rock properties for strata from the coalfields of Nova Scotia. To date, the work has been concentrated in the Sydney Coalfield; although some data has also been obtained from the Springhill area.

In May 1984, a visit by CBCRL staff to the Drummond Mine at Westville, N.S. enabled coal samples from the current underground workings in the No. 1 (Scott Pit) seam to be collected and subsequently tested using the technique of irregular lump point load testing. A previous programme utilizing the technique has already been undertaken in the Sydney Coalfield in order to obtain a "first order approximation" of coal strength properties (1).

This report presents the results obtained from the No. 1 (Scott Pit) seam specimens, Drummond Mine, Westville, N.S. along with a preliminary comparison of the results against those obtained from the Sydney Coalfield.

POINT LOAD TESTING

The point load testing apparatus is shown in Figure 1 and its operation fully described in the Pit Slope Manuel (2).

Essentially, the test involves loading a sample of known shape and size between two points, Figure 2. Extensive work (2,3,4) has reported the factors affecting the test and proposed the method as a valid means of determining a rock strength index.

The point load index, I, is derived using equation (1).

$$I = P/D^2 \qquad \text{Eq 1}$$

where P = Point Load (MPa)

D = Diameter of the Specimen (mm).

In the case of irregular specimen testing, the samples should be roughly spheroidal in shape with a preferred diameter of 50 mm. However, maximum and minimum diameters of 100 mm and 25 mm are acceptable (2). The acceptable ratio of the longest to shortest diameter of the specimen falls between 1.0 and 1.4, Figure 2.

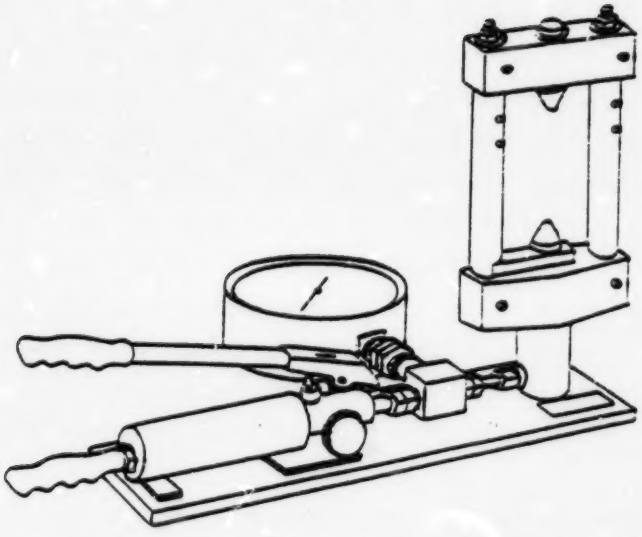
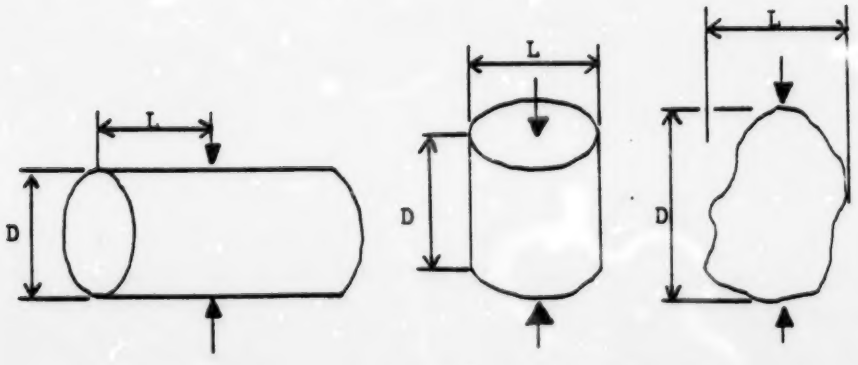


Figure 1 - Point-Load Test Apparatus (Manufactured by ELE Ltd., U.K.) (Ref. 2)



$L > 0.7\ D$

Diametral Test

$\frac{D}{L} = 1.1 \pm 0.05$

Axial Test

$\frac{D}{L} = 1.0$ to 1.4

Irregular Lump Test

Figure 2 - Types of Point Load Strength Tests (Ref. 2)

TESTING PROGRAMME

Samples were collected from the run of mine coal contained in the haulage cars at the top of the access drift. Careful selection was undertaken to elminate those containing stone or obvious poor quality coal. A minimum sample size of 100 mm was collected from the mine and subsequently prepared in the laboratory (reduction to between 25 and 50 mm and roughly spheroidal in shape). Although the samples were collected and transported on a Friday, they were carefully sealed and stored in the laboratory over the weekend and tested Monday morning in order to minimize deterioration effects.

One hundred samples were tested with 50 samples each being tested parallel and perpendicular to the coal bedding. The results were subsequently tabulated and I_{54} values calculated for each of the test samples, along with a mean batch diameter and index strength. The raw data sheets are given in Appendix A.

TEST RESULTS

The diameter of a specimen can exert a significant influence on the derived value, even though the length/diameter criteria are maintained (2,3,4). It is therefore, important to standarize the reporting of index data according to specimen diameter.

The Pit Slope Manuel (2) gives a size correction chart for calculating the I_{54} value to a reference diameter of 50 mm. However, an extensive study by Hassani et al (4) has shown that mathematical equations can be derived which represent the correction curves and therefore avoid the problems associated with distortion and inadequate reproduction of the original chart.

Index values have, therefore, been corrected to 54 mm (standard NX size core) using equation (2), (Ref. 4).

$$\text{Log}_{10}\ Is_{54} = 0.229 + \text{Log}_{10} I - 1.008e^{-0.0274\,(D)} \qquad \text{Eq 2}$$

Where I = Index Strength (MPa)

D = Specimen Diameter (mm)

Hassani et al (4) have also reported relationships between the point load index strength, uniaxial strength and tensile strength as follows:

Uniaxial Compressive Strength Eq 3

$$\sigma_c = 29.24\ Is_{54}$$

Tensile Strength Eq 4

$$Ts = 2.78\ Is_{54}$$

Encouraging results have also been reported for calculating triaxial strength data from point load testing using a variety of established models (4), although no attempt has been made here.

Table 1 - Mean Coal Specimen Values for the No. 1 (Scott Pit) Seam, Drummond Mine, Westville, Nova Scotia

	Parallel to Bedding	Perpendicular to Bedding
Specimen (mm)	43.20	48.80
Load (MPa)	2.04	1.06
Is Value (MPa)	1.34	0.52
Is_{54} Value (MPa)	0.98	0.42
Tensile Strength (MPa)	2.72	1.16
Compressive Strength (MPa)	28.60	12.15

Mean Is, Is_{54}, tensile and compressive strength values are given in Table 1, while the tabulated results are given in Appendix B.

DISCUSSION

In Table 1, the No. 1 (Scott Pit) seam coal has a mean compressive strength of 28 MPa parallel to the bedding and 12 MPa perpendicular to the bedding. It is therefore, stronger parallel rather than perpendicular to the bedding.

Variations in the Is_{54} coal strength values seen in Appendix B may be due to localized changes in coal lithology even though the samples were

carefully selected to eliminate those containing stone or obvious poor quality coal. Similarly, no indication is given as to which coal face or where abouts on the coal face any particular sample originated (floor, middle or roof). It is worth noting that the current Drummond workings are room and pillar and that the mine does not have a history of gas.

Table 2 shows coal properties derived for the Drummond mine along with those obtained for the Sydney Coalfield (1). In general, the Drummond coal appears most similar to that from the Prince Mine, Table 3:

Table 3 - Comparative Is_{54}, Tensile and Compressive Strength Values for the Drummond and Prince Mine Coal

	Drummond Mine	Prince Mine
Compressive Strength (MPa)	28.6	22.0
Tensile Strength (MPa)	12.1	12.0
Is_{54} Anisotropy Index	0.43	0.54

The Drummond coal properties are markedly dissimilar to those seen at the Lingan and No. 26 mines in that it is stronger parallel to the direction of bedding, while at both Lingan and No. 26 the coal is stronger perpendicular to the direction of bedding. The Drummond coal is considerably stronger than that obtained from the NOVACO Point Aconi open pit site.

The Hardgrove grindability values of coal sampled from similar locations at each of the mine sites (5), Table 2, show little indication that the coal strength can be correlated with the grindability index.

Finally, it should be noted that raw data obtained during this programme is presented in Appendices A and B. The reason for the inclusion of this data is that in the future refined or even new techniques for the determination of rock strength parameters from point load test data may become available. It is therefore considered important that the original data used to derive the Drummond coal strengths be available for re-evaluation by future researchers.

Table 2 - Point load index, uniaxial compressive strength, tensile strength and Hardgrove grindability index values of coal, Sydney and Pictou Coalfields, Nova Scotia

Date	Mine Site	Direction of loading relative to bedding	Index strength Is_{54} (MPa)	Calculated Uniaxial Compressive Strength (MPa)	Calculated Tensile Strength (MPa)	Anisotropy Index Is_{54}	Hardgrove grindability index
21/12/83	No. 26	Parallel	0.32	9.3	0.89		
		Perpendicular	0.46	13.5	1.28	1.44	65-70
21/12/83	Lingan	Parallel	0.58	16.9	1.60		
		Perpendicular	1.23	35.8	3.41	2.13	56-62
5/1/84	Lingan	Parallel	0.58	16.9	1.61		
		Perpendicular	1.22	35.7	3.39	2.10	56-62
5/1/84	Prince	Parallel	0.75	22.0	2.10		
		Perpendicular	0.41	12.0	1.14	0.54	59-63
5/1/84	NOVACO	Parallel	0.26	7.6	0.72		
	Point Aconi	Perpendicular	0.18	5.2	0.50	0.69	58
25/5/84	Drummond	Parallel	0.98	28.6	2.72		
		Perpendicular	0.42	12.2	1.16	0.43	53-58

CONCLUSION

The point load index test provides a simple, effective means of deriving rock strength parameters under field and/or laboratory conditions. However, inherent problems do exist with the technique, especially when deriving compressive and tensile strength values from the original index values. The values given in Tables 1 and 2 should, therefore, be treated with caution and used primarily as a 'good first order approximation' of coal strength at the Drummond and Sydney Coalfield mine sites.

ACKNOWLEDGEMENTS

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4. Hassani, F.P., Scoble, M.J. and Whittaker, B.N., "Application of the point load index to strength determination of rock and proposals for a new size correction chart"; Proc. 21st Annual Symp. Rock Mech.; Univ. of Missouri; 1980.

5. Faurschou, D.K., Bonnell, G.W. and Janke, L.C., "Analysis directory of Canadian commercial coals - Supplement No. 4"; CANMET Report 82-13E; CANMET, Energy, Mines and Resources Canada; June 1982.

APPENDIX A

Energy, Mines and Resources CANADA

POINT LOAD STRENGTH INDEX

Sample DRUMMOND MINE - COAL
IRREGULAR LUMP

Date 28-05-84.

Tested by L. Shaun O'Leary

pg. 1 of 3.

Location WESTVILLE - R.O.M*

Borehole N/A Depth N/A

Average water content: N/A %

Sample No. N/A

Average degree of saturation: N/A %

Test Type	Specimen No.	D (DIAM)	P (load)	D^2	Is	Is(50)	Median Value	Notes
POINT LOAD	1	42	2.525	0.0018	1403			
	2	31	2.225	0.0010	2225			
	3	48	0.725	0.0023	315			
	4	42	2.100	0.0018	1167			
	5	32	2.825	0.0010	2825			
	6	25	1.900	0.0006	3167			
	7	57	3.375	0.0032	1055			
	8	25	1.375	0.0006	2192			
	9	61	1.425	0.0037	385			
	10	59	2.025	0.0035	579			
	11	40	1.800	0.0016	1125			
	12	66	3.500	0.0044	795			
	13	52	1.500	0.0027	555			
	14	39	2.075	0.0015	1383			
	15	32	1.850	0.0010	1850			
	16	56	3.125	0.0031	1008			
	17	54	1.125	0.0029	388			
	18	53	2.225	0.0028	795			
	19	47	2.025	0.0022	920			
	20	28	1.725	0.0008	2156			
CUM. TOTAL		889			26288			

Median values of strength index, $I_s(50)$

Parellel to plane of weakness: N/A Mpa

Perpendicular to plane of weakness: N/A Mpa

Anisotropy index, $I_s(50)$ = ——— = N/A

Remarks: * ROM - RUN OF MINE

COAL TESTED PARALLEL TO PLANE.

Energy, Mines and Resources CANADA

POINT LOAD STRENGTH INDEX

Sample DRUMMOND MINE - COAL
IRREGULAR LUMP

Date 28-5-84

Tested by L. Shan Chiang

pg. 2 of 3

Location WESTVILLE - R.O.M.

Borehole N/A Depth N/A

Average water content: N/A %

Sample No. N/A

Average degree of saturation: N/A %

Test Type	Specimen No.	D (DIAM)	P (load)	D^2	Is	Is(50)	Median Value	Notes
POINT LOAD	21	61	1.550	0.0037	419			
	22	50	1.275	0.0025	510			
	23	47	3.200	0.0022	1454			
	24	31	1.825	0.0010	1825			
	25	42	1.975	0.0018	1097			
	26	33	1.675	0.0011	1523			
	27	25	1.750	0.0006	2917			
	28	28	1.775	0.0008	2219			
	29	57	3.625	0.0032	1133			
	30	43	2.125	0.0018	1180			
	31	66	1.850	0.0044	420			
	32	52	2.000	0.0027	741			
	33	64	2.625	0.0041	640			
	34	43	2.000	0.0018	1111			
	35	34	1.825	0.0012	1521			
	36	26	1.150	0.0007	1643			
	37	58	3.175	0.0034	934			
	38	46	2.775	0.0014	1982			
	39	30	1.400	0.0009	1555			
	40	25	2.100	0.0006	3500			
CUM. TOTAL.		861			28324			

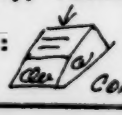
Median values of strength index, $I_s(50)$

Parellel to plane of weakness: N/A Mpa

Perpendicular to plane of weakness: N/A Mpa

Anisotropy index, $I_a(50)$ = ——— = N/A

Remarks:



COAL TESTED PARALLEL TO BEDDING PLANE

Energy, Mines and Resources CANADA

POINT LOAD STRENGTH INDEX

Sample DRUMMOND MINE - COAL IRREGULAR LUMP

Date 28-05-84

Tested by L-Stan Ouellet

Location WESTVILLE - R.O.M.

pg. 383

Borehole N/A Depth N/A

Average water content: N/A %

Sample No. N/A

Average degree of saturation: N/A %

Test Type	Specimen No.	D (DIAM)	P (load)	D^2	Is	Is(50)	Median Value	Notes
POINT LOAD	41	60	2.225	0.0036	618			
	42	55	3.400	0.0030	1133			
	43	27	2.125	0.0007	3036			
	44	41	1.475	0.0017	868			
	45	31	0.975	0.0010	975			
	46	47	2.625	0.0022	1193			
	47	34	1.525	0.0012	1271			
	48	29	1.250	0.0008	1562			
	49	60	1.775	0.0036	493			
	50	27	1.550	0.0007	2214			
CUM.	TOTAL.	411			13363			
TOTAL.	2161				67975			

MEAN I_s = $\frac{67975}{50}$ = 1359.5 KN/m²

= 1.359 MPa

AV. DIAM. = $\frac{2161}{50}$ = 43.22 mm

= 0.043 m

Median values of strength index, $I_s(50)$

Parellel to plane of weakness: N/A Mpa

Perpendicular to plane of weakness: N/A Mpa

Anisotropy index, $I_a(50)$ = ——— = N/A

Remarks: COAL TESTED PARALLEL TO BEDDING PLANE.

Energy, Mines and Resources CANADA

POINT LOAD STRENGTH INDEX

Sample DRUMMOND MINE - COAL
IRREGULAR LUMP

Date 28-05-84

Tested by L. Shaw & Lucy

pg. 1 of 3.

Location WESTVILLE - R.O.M.*

Borehole N/A Depth N/A

Average water content: N/A %

Sample No. N/A

Average degree of saturation: N/A %

Test Type	Specimen No.	D (DIAM)	P (load)	D^2	Is	Is(50)	Median Value	Notes
POINT LOAD	1	59	1.525	0.0035	436			
	2	49	1.225	0.0024	510			
	3	31	0.525	0.0010	525			
	4	25	0.375	0.0006	625			
	5	63	1.800	0.0040	450			
	6	44	0.875	0.0019	460			
	7	35	0.975	0.0012	812			
	8	31	1.450	0.0010	1450			
	9	25	0.675	0.0006	1125			
	10	79	1.975	0.0062	318			
	11	73	1.925	0.0053	363			
	12	47	0.800	0.0022	364			
	13	36	1.450	0.0013	1115			
	14	30	1.000	0.0009	1111			
	15	25	0.625	0.0006	1042			
	16	81	3.000	0.0066	454			
	17	68	0.525	0.0046	114			
	18	64	2.025	0.0041	494			
	19	46	0.975	0.0021	464			
	20	26	0.250	0.0007	357			
CUM. TOTAL		947			12589			

Median values of strength index, $I_s(50)$

Parellel to plane of weakness: N/A Mpa

Perpendicular to plane of weakness: N/A Mpa

Anisotropy index, $I_a(50)$ = ____ = N/A

Remarks: * R.O.M. - RUN OF MINE

COAL TESTED PERPENDICULAR TO BEDDING PLANE

Energy, Mines and Resources CANADA

POINT LOAD STRENGTH INDEX

Sample DRUMMOND MINE - COAL
IRREGULAR LUMP

Date 28-05-84

Tested by L. Stan Ehrey

pg. 2 of 3

Location WESTVILLE - R.O.M.

Borehole N/A Depth N/A

Average water content: N/A %

Sample No. N/A

Average degree of saturation: N/A %

Test Type	Specimen No.	D (DIAM)	P (load)	D^2	Is	Is(50)	Median Value	Notes
POINT LOAD	21	71	2.500	0.0050	500			
	22	66	1.725	0.0044	392			
	23	45	0.850	0.0020	425			
	24	39	0.975	0.0015	650			
	25	85	1.000	0.0072	139			
	26	55	0.400	0.0030	133			
	27	42	0.900	0.0018	500			
	28	32	0.150	0.0010	150			
	29	85	2.200	0.0072	305			
	30	70	0.825	0.0049	168			
	31	54	1.400	0.0029	483			
	32	47	0.950	0.0022	432			
	33	34	0.275	0.0012	229			
	34	25	0.925	0.0006	1542			
	35	68	1.075	0.0046	234			
	36	45	1.125	0.0020	562			
	37	27	0.175	0.0007	250			
	38	62	0.725	0.0038	191			
	39	48	0.650	0.0023	283			
	40	39	1.100	0.0015	733			
CUM. TOTAL.		1039			8301			

Median values of strength index, $I_s(50)$

Parellel to plane of weakness: N/A Mpa

Perpendicular to plane of weakness: N/A Mpa

Anisotropy index, $I_a(50)$ = ——— = N/A

Remarks: COAL TESTED PERPENDICULAR TO BEDDING PLANE

Energy, Mines and Resources CANADA

POINT LOAD STRENGTH INDEX

Sample DRUMMOND MINE - COAL IRREGULAR LUMP

Date 28-05-84.

Tested by L. Jean O'Leary

pg. 3 of 3

Location WESTVILLE - R.O.M.

Borehole N/A Depth N/A

Average water content: N/A %

Sample No. N/A

Average degree of saturation: N/A %

Test Type	Specimen No.	D (DIAM)	P (load)	D^2	Is	Is(50)	Median Value	Notes
POINT LOAD	41	26	0.375	0.0008	469			
	42	76	1.325	0.0058	228			
	43	63	0.550	0.0040	137			
	44	52	0.325	0.0027	120			
	45	31	1.275	0.0010	1275			
	46	63	1.875	0.0040	469			
	47	50	1.525	0.0025	610			
	48	41	0.200	0.0017	118			
	49	34	1.125	0.0012	937			
	50	25	0.525	0.0006	875			
CUM	TOTAL	463			5238			

TOTAL. 2449 26128

MEAN I_S = $\frac{26128}{50}$ = 522.56 KN/M²

= 0.523 MPa

AVER. DIAM. = $\frac{2449}{50}$ = 48.98 mm = 0.049 m

Median values of strength index, $I_s(50)$

Parellel to plane of weakness: N/A Mpa

Perpendicular to plane of weakness: N/A Mpa

Anisotropy index, $I_a(50)$ = ____ = N/A

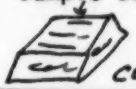
Remarks: COAL TESTED PERPENDICULAR TO BEDDING PLANE

APPENDIX B

CAPE BRETON COAL RESEARCH LABORATORY

Sample Location DRUMMOND MINE - WESTVILLE

Sample Description COAL - IRREGULAR LUMP - RUN OF MINE Date MAY 28/84



COAL TESTED PARALLEL TO BEDDING PLANE

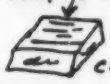
pg. 1 of 3

Specimen Diameter	Load	Is	Is 54	Tensile Strength	Uniaxial Compressive Strength	
42	2.525	1.43	1.17	3.25	34.20	
31	2.225	2.31	1.46	4.07	42.81	
48	0.725	0.31	0.31	0.80	8.40	
42	2.100	1.19	0.97	2.70	28.45	
32	2.825	2.76	1.79	4.98	52.39	
25	1.900	1.61	1.61	4.48	47.13	
57	3.375	1.04	1.08	3.01	31.73	
25	1.375	1.17	1.17	3.24	34.11	
61	1.425	0.38	0.42	1.17	12.30	
59	2.025	0.58	0.62	1.73	18.24	
40	1.800	1.12	0.88	2.45	25.80	
66	3.500	0.80	0.93	2.59	27.28	
52	1.500	0.55	0.54	1.50	15.79	
39	2.075	1.36	1.05	2.91	30.62	
32	1.850	1.81	1.17	3.26	34.31	
56	3.125	1.00	1.03	2.86	30.04	
54	1.125	0.39	0.39	1.07	11.31	
53	2.225	0.79	0.78	2.17	22.88	
47	2.025	0.92	0.82	2.29	24.05	
28	1.725	2.20	1.28	3.55	37.39	

CAPE BRETON COAL RESEARCH LABORATORY

Sample Location DRUMMOND MINE - WESTVILLE

Sample Description COAL - IRREGULAR LUMP - RUN OF MINE Date MAY 28/84



COAL TESTED PARALLEL TO BEDDING PLANE

pg. 2 of 3

Specimen Diameter	Load	Is	Is 54	Tensile Strength	Uniaxial Compressive Strength	
61	1.550	0.42	0.46	1.27	13.38	
50	1.275	0.51	0.48	1.34	14.07	
47	3.200	1.45	1.30	3.61	38.00	
31	1.825	1.90	1.20	3.34	35.11	
42	1.975	1.12	0.91	2.54	26.75	
33	1.675	1.54	1.02	2.85	29.97	
25	1.750	2.80	1.48	4.13	43.41	
28	1.775	2.26	1.31	3.66	38.47	
57	3.625	1.12	1.17	3.24	34.09	
43	2.125	1.15	0.96	2.66	28.01	
66	1.850	0.42	0.49	1.37	14.42	
52	2.000	0.74	0.72	2.00	21.05	
64	2.625	0.64	0.73	2.02	21.30	
43	2.000	1.08	0.90	2.51	26.36	
34	1.825	1.58	1.08	3.00	31.55	
26	1.150	1.70	0.93	2.59	27.22	
58	3.175	0.94	1.00	2.78	29.21	
46	2.775	1.31	1.56	3.21	33.80	
30	1.400	1.56	0.96	2.66	27.98	
25	2.100	3.36	1.78	4.95	52.09	

CAPE BRETON COAL RESEARCH LABORATORY

Sample Location DRUMMOND MINE - WESTVILLE

Sample Description COAL - IRREGULAR LUMPS - RUN OF MINE Date MAY 28/84.

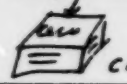
pg. 3 of 3

Specimen Diameter	Load	Is	Is 54	Tensile Strength	Uniaxial Compressive Strength	
60	2.225	0.62	0.67	1.86	19.62	
55	3.400	1.12	1.14	3.18	33.41	
27	2.125	2.91	1.64	4.57	48.08	
41	1.475	0.88	0.70	1.95	20.55	
31	0.975	1.01	0.64	1.78	18.76	
47	2.625	1.19	1.07	2.96	31.17	
34	1.525	1.32	0.90	2.51	26.36	
29	1.250	1.49	0.89	2.47	26.00	
60	1.775	0.49	0.53	1.49	15.65	
27	1.550	2.13	1.20	3.33	35.07	
		AVERAGES				
43.22	2.04	1.34	0.98	2.72	28.60	

CAPE BRETON COAL RESEARCH LABORATORY

Sample Location DRUMMOND MINE - WESTVILLE

Sample Description COAL - IRREGULAR LUMP - RUN OF MINE Date MAY 28/84



COAL TESTED PERPENDICULAR TO BEDDING PLANE

Pg. 183.

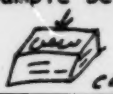
Specimen Diameter	Load	Is	Is 54	Tensile Strength	Uniaxial Compressive Strength	
59	1.525	0.44	0.47	1.31	13.73	
49	1.225	0.51	0.47	1.32	13.85	
31	0.525	0.55	0.34	0.96	10.10	
25	0.375	0.60	0.32	0.88	9.30	
63	1.800	0.45	0.51	1.42	14.91	
44	0.875	0.45	0.38	1.07	11.23	
35	0.975	0.80	0.56	1.55	16.30	
31	1.450	1.51	0.95	2.65	27.90	
25	0.675	1.08	0.57	1.59	16.74	
79	1.975	0.32	0.41	1.14	12.03	
73	1.925	0.36	0.45	1.25	13.10	
47	0.800	0.36	0.32	0.90	9.50	
36	1.450	1.12	0.80	2.23	23.47	
30	1.000	1.11	0.68	1.90	19.99	
25	0.625	1.00	0.53	1.47	15.50	
81	3.000	0.46	0.60	1.68	17.63	
68	0.525	0.11	0.13	0.37	3.93	
64	2.025	0.49	0.56	1.56	16.43	
46	0.975	0.46	0.41	1.13	11.88	
26	0.250	0.37	0.20	0.56	5.92	

CAPE BRETON COAL RESEARCH LABORATORY

Sample Location DRUMMOND MINE - WESTVILLE

Sample Description COAL - IRREGULAR LUMP - RUN OF MINE

Date MAY 28/84



COAL TESTED PERPENDICULAR TO BEDDING PLANE

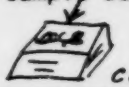
pg. 2 of 3.

Specimen Diameter	Load	Is	Is 54	Tensile Strength	Uniaxial Compressive Strength	
71	2.500	0.50	0.60	1.68	17.67	
66	1.725	0.40	0.46	1.28	13.45	
45	0.850	0.42	0.36	1.01	10.62	
39	0.975	0.64	0.49	1.37	14.39	
85	1.000	0.14	0.19	0.52	5.48	
55	0.400	0.13	0.13	0.37	3.93	
42	0.900	0.51	0.42	1.16	12.19	
32	0.150	0.15	0.09	0.26	2.78	
85	2.200	0.30	0.41	1.15	12.05	
70	0.825	0.17	0.20	0.56	5.94	
54	1.400	0.48	0.48	1.34	14.07	
47	0.950	0.43	0.39	1.07	11.28	
34	0.275	0.24	0.16	0.45	4.75	
25	0.925	1.48	0.78	2.18	22.95	
68	1.075	0.23	0.27	0.77	8.05	
45	1.125	0.56	0.48	1.34	14.06	
27	0.175	0.24	0.13	0.38	3.96	
62	0.725	0.19	0.21	0.58	6.13	
48	0.650	0.28	0.26	0.72	7.53	
39	1.100	0.72	0.55	1.54	16.23	

CAPE BRETON COAL RESEARCH LABORATORY

Sample Location DRUMMOND MINE - WESTVILLE

Sample Description COAL - IRREGULAR LUMP - RUN OF MINE Date MAY 28/84



COAL TESTED PERPENDICULAR TO BEDDING PLANE.

Pg. 3 of 3

Specimen Diameter	Load	Is	Is 54	Tensile Strength	Uniaxial Compressive Strength	
28	0.375	0.48	0.28	0.77	8.13	
76	1.325	0.23	0.29	0.81	8.53	
63	0.550	0.14	0.16	0.43	4.55	
52	0.325	0.12	0.12	0.32	3.42	
31	1.275	1.33	0.84	2.33	24.53	
63	1.875	0.47	0.53	1.48	15.53	
50	1.525	0.61	0.57	1.60	16.82	
41	0.200	0.12	0.95	0.26	2.79	
34	1.125	0.97	0.66	1.85	19.45	
25	0.525	0.84	0.44	1.24	13.02	
		AVERAGES				
48.78	1.06	0.52	0.42	1.16	12.15	